

Open-source  
SpaceWire CODEC IP Core  
User Manual  
Ver.0.40

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## Revision history

Version number	date	Contents	remarks
Ver.0.10	2013/11/13	First edition	
Ver.0.20	2013/11/15	<b>Document renamed</b> Font change Japanese "MS" Ming Dynasty" Alphanumerical "Times New Roman" Change notation Add a space between words <b>"SpaceWireCODECIP"→"SpaceWire CODEC IP"</b>	
Ver.0.30	2013/12/12	10.2Clock example2Added explanation of clock Added a picture	
Ver.0.40	2013/12/17	frame and auxiliary lines to the figure <b>8. 8.Added character code note to file structure</b>	

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## 1. Overview

SpaceWire is a communication for data communication between onboard components in a spacecraft (satellite). It / F And communication protocol specifications.

SpaceWire CODEC IP is from Xilinx, Altera or FPGA. To target SpaceWire for the purpose of implementation VHDL is the core.  
ECSS-E-ST-50-12C Designed to fit, maximum communication rate 100Mbps Corresponds to.

RMAP Target IP or SpaceWire Router IP By incorporating it in, you can collect telemetry data and SpaceWire It is possible to realize the router function.

## 2. License And disclaimer

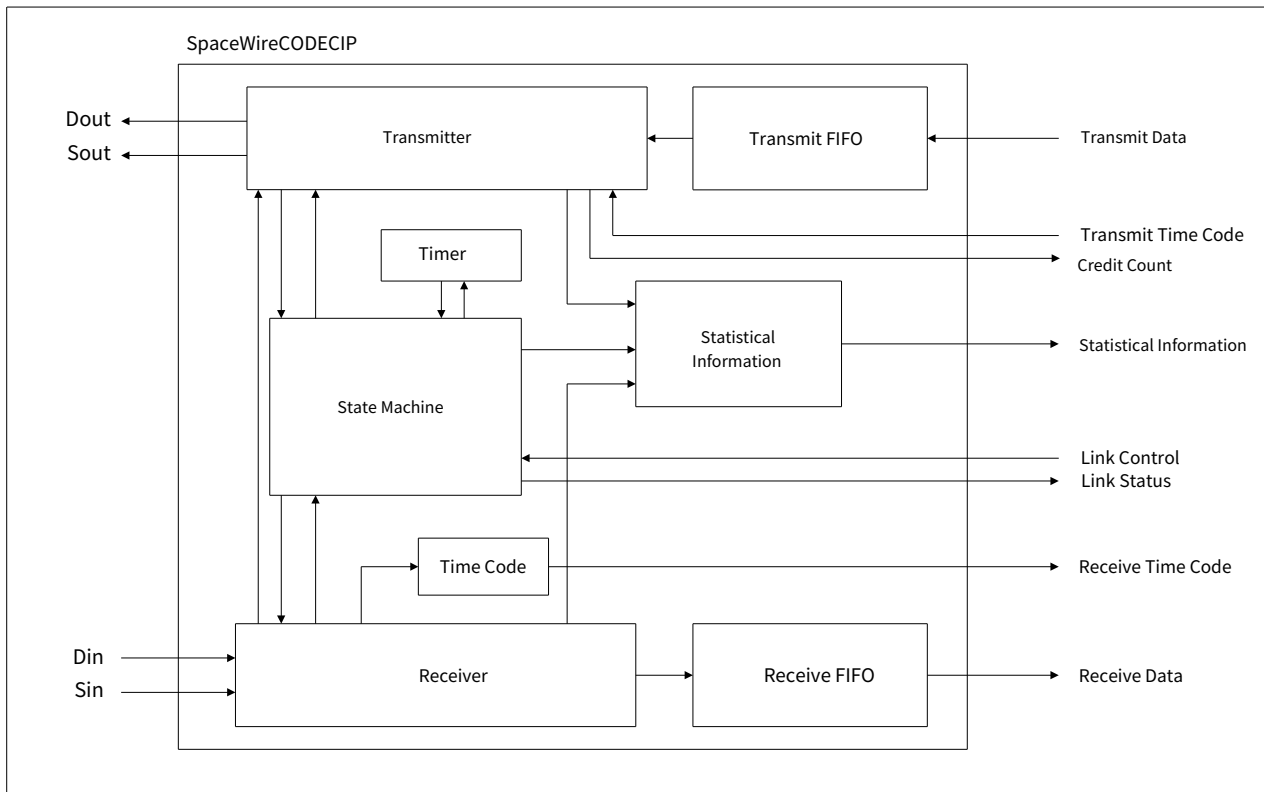
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### 3. Block diagram

SpaceWire CODEC IP The block diagram is shown.



SpaceWire Input from Receiver Decodes ReceiveFIFO Write to. Transmit FIFO The data written in Transmitter Converts to data and strobe signals SpaceWire Output to.

## 4. Module function

### 4.1. Transmitter

StateMachine Only when you have permission to send from Transmit FIFO Received the data written to FCT Minutes N-Char Only converted to data and strobe signals SpaceWire When there is no data to send or the number of data that can be sent is 0 At that time NULL Is being output.

FCT The number of transmissions and receptions Transmitter Is managed by.

Recever But FCT Every time you receiveTransmitter Adds the number that can be sent by 8Transmitter ButN-Char When you send, the number that can be sent is subtracted by one.

also,Transmitter But FCT When you send, the number of receivables is added by 8.Recever But N-Char When is received, the number that can be received is subtracted by one.

The number that can be sent is 56 When the above is reached or the number of receivables is 0 At that time Recever But N-Char When you receive StateMachine Outputs a credit error to.

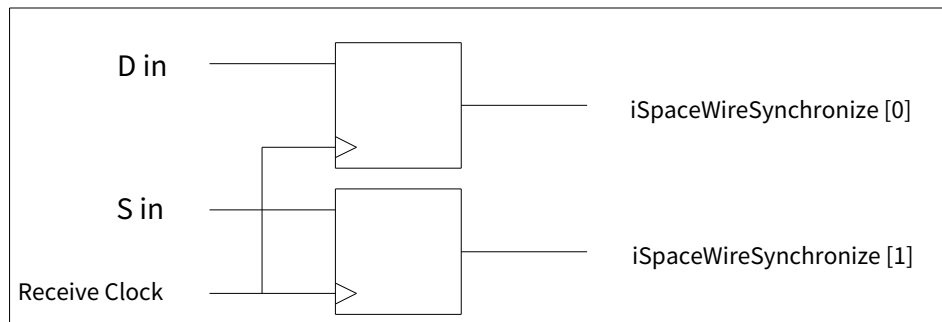
The transmission rate is Transmit Clock When transmitClockDivideValue It is determined by the value.

LinkUP Above all transmitClockDivideValue You can change the transmission rate by changing the value of,Link Link At the time of initialization 10Mbps Works with.

### 4.2. Receiver

The data and strobe signal are synchronized with the internal clock before decoding.

The figure below shows the synchronization of data and strobe signals.

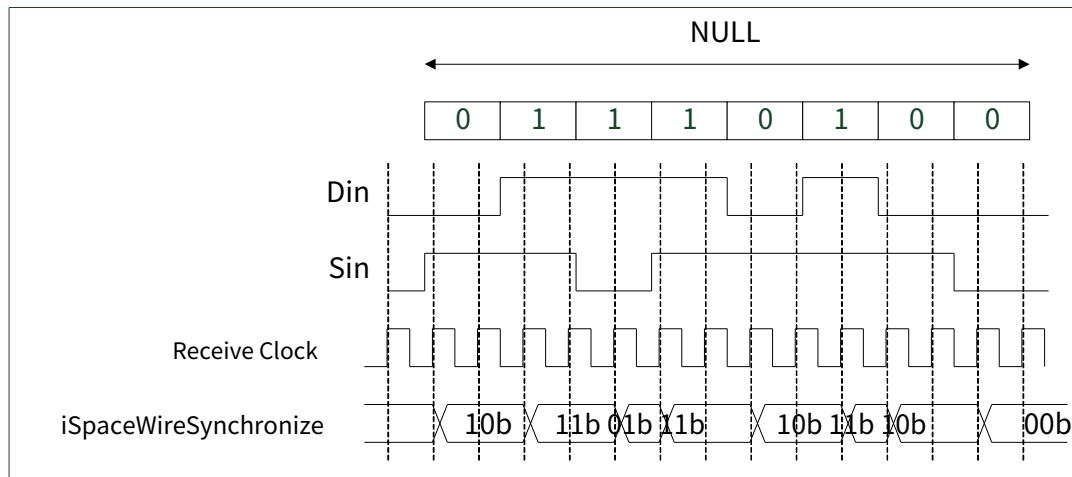


N-Char (data,EOP,EEP)When you receive the data ReceiveFIFO Write to StateMachine Will be notified.NULL, FCT,TimeCode Even when you receive StateMachine Will be notified toFCT only Transmitter Will also be notified.

N-Char (data,EOP,EEP)except ReceiveFIFO Will not be written to.

When an escape error or parity error is received, the data is discarded andStateMachine Will be notified to. Also, data and strobe signals850ns If it does not change, it is considered as a disconnection error. StateMachine Will be notified.

At the time of receptionReceiverThe timing chart is shown in the figure below.



### 4.3. StateMachine

It manages the initialization of the link interface, normal operation, and error recovery processing.

**Error Reset** • • • EnableTransmitter,EnableReceiverBut"L " become,Transmitter,Receiverof  
The operation will stop.  
6.4usAfter the lapseErrorWaitTransition to.

**ErrorWait** • • • EnableReceiveBut"H " become,ReceiverWorks.  
12.8usAfter the lapseReadyTransition to.  
ReceiverButError ErrorWhen it is detectedError ResetTransition to.

**Ready** • • • LinkEnableBut"H " To become andStarted. Started.Transition to.  
ReceiverButError ErrorWhen it is detectedError ResetTransition to.

Started. Started. • • • EnableTransmit,SendNULLsBut"H " become,TransmitterteethNULLWill be sent.  
EnableTransmit,SendNULLsBut"H " become,TransmitterteethNULLWill be sent. Receiver  
ButNULLWhen you receiveConnectingTransition to.  
ReceiverButError ErrorDetected orStarted. Started.Transition to12.8usAfter the lapseError ResetTransition to.

**Connecting** • • • SendFCTsBut"H " become,TransmitterteethFCTWill be sent.  
ReceiverButFCTWhen you receiveRunTransition to.  
ReceiverButError ErrorDetected orConectingTransition to12.8usAfter the lapseError ResetTransition to.

**Run** • • • SendTimeCode,SendNCharBut"H " become,TransmitterteethTimeCode,N-Charof  
You will be able to send.  
ReceiverButError ErrorWhen it is detectedError ResetTransition to.

## 4.4. Timer

Link Link Sometimes used for initialization 6.4us,12.8us Generating a timer.

## 4.5. TimeCode

Receiver ButTimeCodeoff received, check if the value is 1 larger than the current value.TickOut Is output. If you receive an invalid timecode, it will update the current value, TickOut Does not output.

## 4.6. Statistical Information

Transmitter Sent EOP,EEP,N-Char..Receiver Received EOP,EEP,N-Char.. During the link-up sequenceLinkUP,LinkDown I'm counting the number of times. Each information is maximum 4294967296 You can count the number of times. statisticalInformationClear of"H " You can clear the total number of times by setting.

## 4.7. Transmit FIFO

Host side wants to send N-Char Write  $9 \times 64$ FIFO is.

Max 56 Of pieces N-Char Can be written,56 When writing individual data FULL But"H " Become.

## 4.8. ReceiveFIFO

Receiver Decoded N-Char (data,EOP,EEP)Write  $9 \times 64$ FIFO is.

Max56Of piecesN-Char Has been written,FIFOWhen no data is written toEmptyBut"H " Will be.



## 5. Interface signal

SpaceWire CODEC IP Each Clock Works on the rising edge of. The input signal is "H" By setting, the function will be enabled. The output signal is "H" At that time, the function is enabled. SpaceWire CODEC IP The interface signals are shown below.

Signal name	I / O	Explanation
Clock	I	System clock
transmitClock	I	Transmission clock
receiveClock	I	Receive clock
Reset	I	reset
transmitFIFOWriteEnable	I	Write permission
transmitFIFODataIn [8: 0]	I	Write data
transmitFIFOFull	O	FULL
transmitFIFODataCount [5: 0]	O	Number of data saved
receiveFIFOReadEnable	I	Read permission
receiveFIFODataOut [8: 0]	O	Read data
receiveFIFOFull	O	FULL
receiveFIFOEmpty	O	Empty
receiveFIFODataCount [5: 0]	O	Number of data saved
tickIn	I	Timecode transmission
timeIn [5: 0]	I	Transmission time code
controlFlagsIn [1: 0]	I	Transmission timecode control flag
tickOut	O	Received time code
timeOut [5: 0]	O	Received time code
controlFlagsOut [1: 0]	O	Receive timecode control flag
linkStart	I	"H" By entering LinkStart To enable. Link-up sequence is automatic Ready from Started. Started. Transition to. "L" By entering LinkStart Disables.
linkDisable linkDisable	I	"H" Link by entering Disable Disable To "L" By entering Disable Disable Is released. LinkStart as well as AutoStart teeth LinkDisable But "L" It is valid only when.
autoStart	I	"H" By entering AutoStart To enable. NULL The link will be started by receiving. "L" By entering AutoStart Disables.
transmitClockDivideValue [5: 0]	I	Transfer rate setting value after link-up Transfer rate = $\frac{\text{Transimit Clock [MHz]}}{(\text{TransmitClockDivideValue}-1)}$
creditCount [5: 0]	O	Link partner credit count (number of sendables) Receiver But FCT When you receive Credit Count of 8 Add up one by one. Transmitter But N-Char When you send Credit Count Is subtracted by 1.

outstandingCount [5: 0]	O	Credit count of own node (receivable number) Transmitter But FCT When you send Outstanding Count of 8 Add up one by one. Receiver But N-Char When you receive Outstanding Count Is subtracted by 1.
transmitActivity	O	Reading data
receiveActivity	O	Writing data
spaceWireDataIn	I	SpaceWireData input
spaceWireStrobeIn	I	SpaceWireStrobe input
spaceWireDataOut	O	SpaceWireData output
spaceWireStrobeOut	O	SpaceWireStrobe output
linkStatus [15: 0]	O	Link status information
linkStatus [0]		EnableTransmit The link-up sequence is Started. Started. When transitioning to,H ” Will be. An error during the link down or link up sequence "L ” Become.
linkStatus [1]		EnableReceive The link-up sequence is ErrorWait When transitioning to,H ” Will be. An error during the link down or link up sequence "L ” Become.
linkStatus [2]		SendNULLs The link-up sequence is Started. Started. When transitioning to,H ” Will be. An error during the link down or link up sequence "L ” Become.
linkStatus [3]		SendFCTs The link-up sequence is Connecting When transitioning to,H ” Will be. An error during the link down or link up sequence "L ” Become.
linkStatus [4]		SendNChar The link-up sequence is Run When transitioning to,H ” Will be. An error during the link down or link up sequence "L ” Become.
linkStatus [5]		SendTimeCode The link-up sequence is Run When transitioning to,H ” Will be. An error during the link down or link up sequence "L ” Become.
linkStatus [6]		Reserve “0” Fixed
linkStatus [7]		SpaceWireReset The link-up sequence is Error Reset When transitioning to,H ” Will be. The link-up sequence isErrorWait When transitioning to,L ” Will be.
linkStatus [8]		Link establishment signal The link-up sequence is Run When transitioning to,H ” Will be. When you link down,L ” Will be.
linkStatus [9]		Transmitter But N-Char When you send 1 Clock only “H ” Will be.
linkStatus [10]		Receiver But N-Char When you receive 1 Clock only “H ” Will be.
linkStatus [11]		Receiver But NULL When you receive 1 Clock only “H ” Will be.
linkStatus [12]		Receiver But FCT When you receive 1 Clock only “H ” Will be.
linkStatus [13]		Receiver But EOP When you receive 1 Clock only “H ” Will be.
linkStatus [14]		Receiver But EEP When you receive 1 Clock only “H ” Will be.
linkStatus [15]		Reserve “0” Fixed

errorStatus [7: 0]	O	Link error information
errorStatus [0]		CharacterSequenceError Unexpected during link-up sequence FCT or N-Char When you receive "H" Will be. The link-up sequence is Error Reset When transitioning to,L " Will be.
errorStatus [1]		CreditError Credit CountBut56When it becomes more thanOutstanding CountBut0At that timeN-Char When you receiveH " Will be. The link-up sequence is Error Reset When transitioning to,L " Will be.
errorStatus [2]		RxErr EnableReceive But"H " At that time ParityError Or DisconnectError Or ESCError When it detectsH " Will be. The link-up sequence isError Reset When transitioning to,L " Will be.
errorStatus [3]		Reseve "0" Fixed
errorStatus [4]		Parity Error EnableReceive But"H " When a parity error is detected at, "H " Will be. The link-up sequence is Error Reset When transitioning to,L " Will be.
errorStatus [5]		DisconnectError EnableReceive But"H " At that time, the data and strobe signal 850ns If there is no change,H " Will be. The link-up sequence is Error Reset When transitioning to,L " Will be.
errorStatus [6]		ESCError EnableReceiveBut"H " At that timeEscThe control character received after the character FCT At times other thanH " Will be. The link-up sequence is Error Reset When transitioning to,L " Will be.
errorStatus [7]		Reseve "0" Fixed
statisticalInformationClear	I	"H" The statistics will be cleared by entering. "L" Start counting by entering.
statisticalInformation 8× [31: 0]	O	Statistics
statisticalInformation 0 [31: 0]		Transmitter But EOP Number of totals sent
statisticalInformation 1 [31: 0]		Receiver But EOP Number of totals received
statisticalInformation 2 [31: 0]		Transmitter But EEP Number of totals sent
statisticalInformation 3 [31: 0]		Receiver But EEP Number of totals received
statisticalInformation 4 [31: 0]		Transmitter But N-Char Number of totals sent
statisticalInformation 5 [31: 0]		Receiver But N-Char Number of totals received
statisticalInformation 6 [31: 0]		The total number of times the link-up sequence has been linked up
statisticalInformation 7 [31: 0]		The total number of times the link-up sequence has been linked down

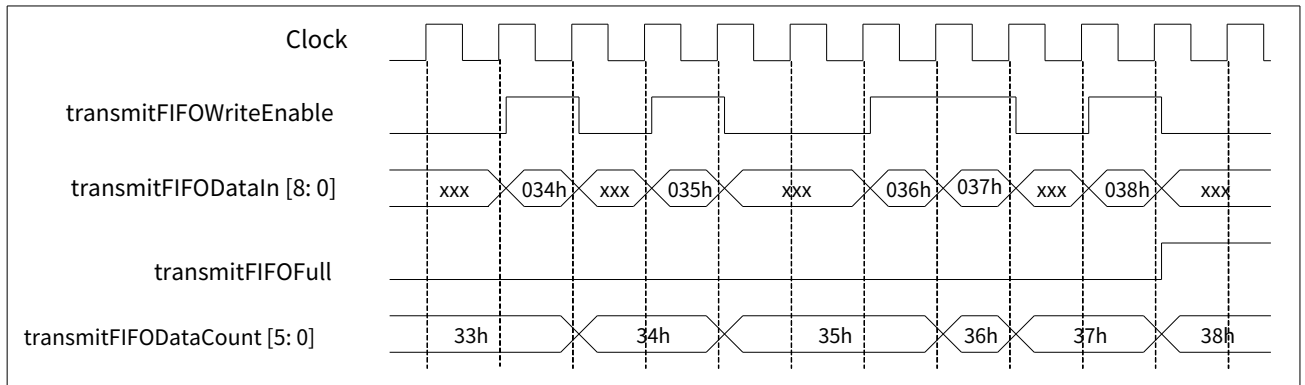
## 6. Timing diagram

SpaceWire CODEC IP The timing chart of the interface signal is shown.

### 6.1. Transmit FIFO

Host side wants to send N-Char Write FIFO is.

Transmit FIFO The timing chart at the time of writing is shown in the figure below.



Clock At the start of WriteEnable But "H" If FIFO You can write data to. 56 When writing data FIFO Full But "H" Will be.

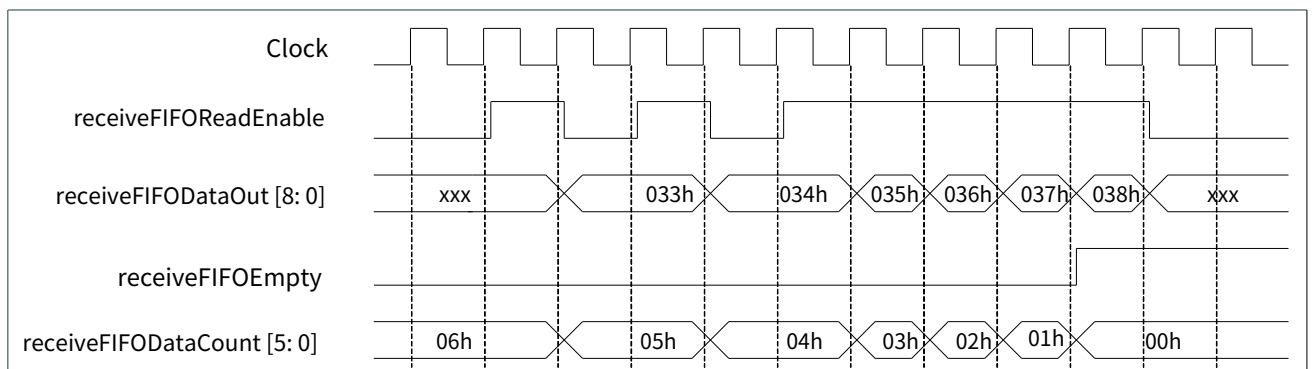
\*FIFO Full But "H" Even in the case of, then7 You can write up to the data, but 8 If you write more than the data DataCount Please note that it will be misaligned and you will not be able to write correctly.

### 6.2. ReceiveFIFO

SpaceWire Received at N-Char Is written FIFO is.

EOP,EEP Other control characters ReceiveFIFO Will not be written to.

ReceiveFIFO The timing chart at the time of reading is shown in the figure below.

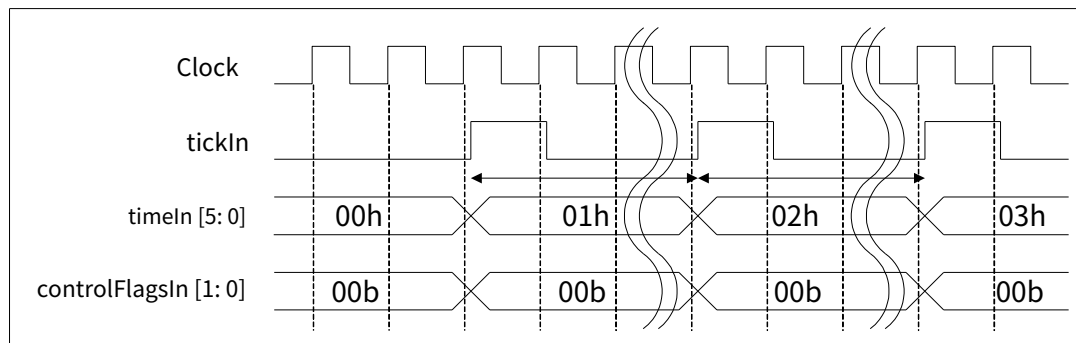


Clock At the start of ReadEnable But "H" If FIFO You can read the data from.

\*FIFO Empty But "H" Data cannot be read at the time of, so be careful when reading continuously.

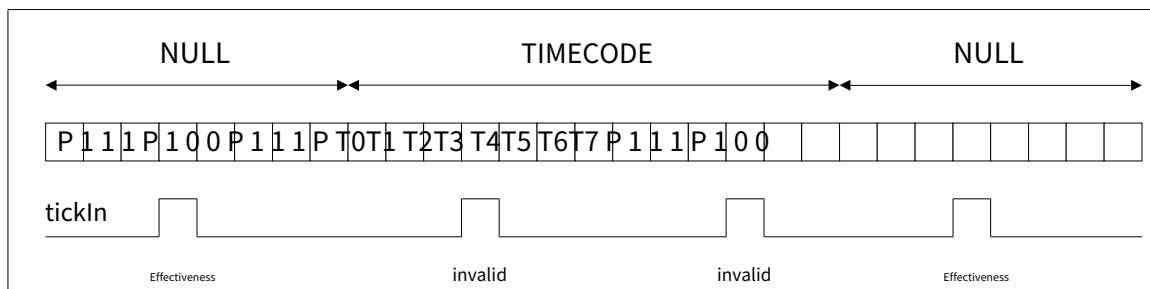
### 6.3. Transmission time code

The timing chart when sending the time code is shown in the figure below.



Clock Synchronous TickIn When you input a signal TimeIn,ControlFlagsin Sends the value of as a timecode. TimeIn,ControlFlagsin The value of TickIn Please update every time.

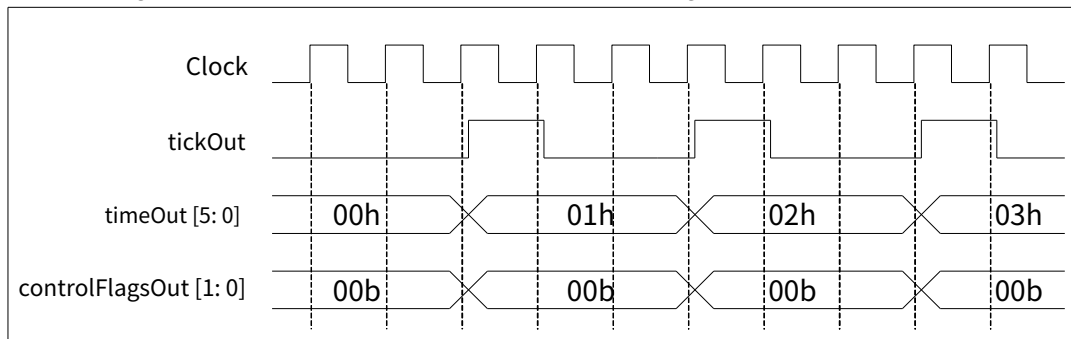
TickIn The signal timing chart is shown in the figure below.



Transmitter Is sending timecode TickIn Ignore the signal. TickIn Cycle is the transmission rate cycle twenty five Please allow more than double the time.

### 6.4. Received time code

The timing chart when the time code is received is shown in the figure below.



If you receive a timecode Clock Synchronized to TickOut The signal is output. The received timecode value isTimeOut,ControlFlagsOut Output to.

## 7. Package

Declared in the package Constant. For the declaration, change the set value according to the input clock. Constant.  
The declaration is shown below.

Constant. Name	type	Bit width	Explanation
gDisconnectCountValue	integer	0 to 255	<p>Disconnection error time setting value.</p> <p>DS The signal is about 850ns If it does not change for a while, a disconnection error will occur.</p> <p>Setting value = <math>\frac{850}{T}</math>      T = ReceiveClock Cycle</p> <p>The default value is 141 (166MHz)Is set to.</p>
gTimer6p4usValue	integer	0 to 1023	<p>6.4 After Signal generation time setting value.</p> <p>Necessary for state transition of state machine after6p4us Signal 6.4us It is generated by.</p> <p>Setting value = <math>\frac{6400}{T}</math>      T = Clock Cycle</p> <p>The default value is 320 (50MHz)Is set to.</p>
gTimer12p8usValue	integer	0 to 2047	<p>12.8After Signal generation time setting value.</p> <p>Necessary for state transition of state machine after12p8us Signal 12.8us It is generated by.</p> <p>Setting value = <math>\frac{12800}{T}</math>      T = Clock Cycle</p> <p>The default value is 640 (50MHz)Is set to.</p>
gInitializeTransmitClock DivideValue	std_logic _vecto	6	<p>Transmission rate setting value at initialization.</p> <p>The transmission rate at initialization 10Mbps Set to be.</p> <p>Setting value = <math>\frac{f \text{ [MHz]}}{\text{Ten}} - 1</math>      f = Transmit Clock</p> <p>The default value is 9 (100MHz)Is set to.</p>

## 8. File structure

SpaceWire CODEC IP The file structure is shown below.

file name	Explanation
SpaceWireCODECIP.vhdl	SpaceWire CODEC IP Top module
SpaceWireCODECIPReceiverSynchronize.vhdl	SpaceWire Receive module
SpaceWireCODECIPTransmitter.vhdl	SpaceWire Send module
SpaceWireCODECIPStateMachine.vhdl	Link interface state machine module
SpaceWireCODECIPTimer.vhdl	Timer module
SpaceWireCODECIPTimeCodeControl.vhdl	Timecode receiving module
SpaceWireCODECIPStatisticalInformationCount.vhdl	Statistics counter module
SpaceWireCODECIPFIFO9x64.vhdl	FIFO _RTL module
SpaceWireCODECIPLinkInterface.vhdl	Link interface top module
SpaceWireCODECIP SynchronizeOnePulse.vhdl	Clock synchronization module
SpaceWireCODECIPPackage.vhdl	Constant. Declaration package

\* The character code of the above source is UTF-8 is.

## 9. Performance

SpaceWire CODEC IP The resource utilization of is shown below.

- device       Xilinx Made Spartan-6 XC6SLX75
- Synthesis tool ISE 14.4

Resource utilization depends on synthesis options and devices.

Module name	Flip-Flops	LUT	Slices	RAM (LUT) Inside)
SpaceWireCODECIP	691	662	306	twenty four
SpaceWireCODECIPReceiverSynchronize	59	104	39 39	0
SpaceWireCODECIPTransmitter	114 114	116	63 63	0
SpaceWireCODECIPStateMachine	28 28	30	27	0
SpaceWireCODECIPTimer	twenty four	twenty five	twenty four	0
SpaceWireCODECIPTimeCodeControl	twenty five	9	9	0
SpaceWireCODECIPStatisticalInformationCount	274	266	86	0
SpaceWireCODECIPFIFO9x64	82	77 77	twenty five	12



## 10. Timing constraints

### 10.1.ucf File

Timing constraints are needed to ensure accurate timing of the composite circuit.  
Timing constraints are required for all clock transfers.

Communication rate 100Mbps The time timing constraints are shown below.

```
clock          = 50MHz
transmitClock = 100MHz
receiveClock = 166.6MHz
```

```
NET "clock"      TNM_NET  == "SYS_CLK";
NET "transmitClock" TNM_NET == "TX_CLK";
NET "receiveClock" TNM_NET == "RX_CLK";
```

```
TIMESPEC TS_SYS_CLK_to_TX_CLK  = FROM  "SYS_CLK" TO "TX_CLK" TIG;
TIMESPEC TS_TX_CLK_to_SYS_CLK  = FROM  "TX_CLK" TO "SYS_CLK" TIG;
TIMESPEC TS_TX_CLK_to_RX_CLK   = FROM  "TX_CLK" TO "RX_CLK" TIG;
TIMESPEC TS_RX_CLK_to_TX_CLK   = FROM  "RX_CLK" TO "TX_CLK" TIG;
TIMESPEC TS_SYS_CLK_to_RX_CLK  = FROM  "SYS_CLK" TO "RX_CLK" TIG;
TIMESPEC TS_RX_CLK_to_SYS_CLK  = FROM  "RX_CLK" TO "SYS_CLK" TIG;
```

```
TIMESPEC "TS_clk"      == PERIOD  "SYS_CLK" 20 ns HIGH 50%;
TIMESPEC "TS_txclk"    == PERIOD  "TX_CLK"   10 ns HIGH 50%;
TIMESPEC "TS_rxclk"    == PERIOD  "RX_CLK"    ns HIGH 50%;
```

## 10.2. Clock

SpaceWire CODEC IP for Clock, Transmit Clock, Receive Clock Must be supplied.

Communication rate 100Mbps The recommended clock for the hour is shown below.

Clock	50-100MHz
Transmit Clock	100.0MHz
Receive Clock	166.6MHz
gInitializeTransmitClockDivideValue	001001
gDisconnectCountValue	141

Input clock conditions

- Receive Clock Is the reception rate 1.5 1.5 Enter a frequency that is about twice as high.
- Transmit Clock of 100MHz When using in the following Receive Clock Please lower by the same ratio.  
Transmit Clock When lowering Receive Clock If you do not lower by the same ratio, the code will be controlled by the transmission / reception rate used. FCT If you receive continuously, it may not be processed correctly.

Example 1: Transmit Clock of 100MHz When used below.

Clock	50.0MHz
Transmit Clock	50.0MHz
Receive Clock	83.3MHz
gInitializeTransmitClockDivideValue	000100
gDisconnectCountValue	71 71

Example 2: FCT A combination of clocks that cannot handle continuous reception correctly.

Clock	50.0MHz
Transmit Clock	10.0MHz
Receive Clock	166.6MHz
gInitializeTransmitClockDivideValue	000000
gDisconnectCountValue	141

Transmission rate at the input clock of Example 210Mbps, Reception rate100MbpsWhen used inTransmit ClockCycle 100ns within FCT If you receive continuously2 More than one FCT Despite receiving1 For each piece FCT Will be processed as.

If this condition continues, the credit count will eventually increase. 8 It may not increase more.